Censusing Double-crested Cormorants (*Phalacrocorax auritus*) at their Winter Roosts in the Delta Region of Mississippi

JAMES F. GLAHN[1], ALAN MAY[2,3], KEVIN BRUCE[2], AND DAVID REINHOLD[1]

[1]Denver Wildlife Research Center
USDA/APHIS/Animal Damage Control
P.O. Drawer 6099
Mississippi State, MS 39762-6099 USA

[2]USDA/APHIS/Animal Damage Control
P.O. Box 316
Stoneville, MS 38776 USA

[3]Present address: USDA/APHIS/Animal Damage Control
P.O. Box 30003
Department 4901
Las Cruces, NM 88003 USA

Abstract.—Wintering Double-crested Cormorants (*Phalacrocorax auritus*) were censused at all identified night roost sites in the Delta Region of Mississippi during the winters of 1991-92 and 1992-93 using aerial surveys and systematic ground surveys in mid-December, mid-February and the end of March. Aerial surveys of primary river drainages were particularly useful in locating previously unidentified roost sites and aerial counts were highly correlated with ground counts of the same sites taken within eight days of each other. Despite an increase in monitoring effort and shifts in populations due to human disturbance, there were no significant differences detected in cormorant populations wintering in this region over the past four years. However, mid- February counts were significantly higher than either December or March counts and numbered approximately 30,000 ± 2,000 individuals. Although up to 34 sites have been monitored to conduct these censuses, only between six and twelve sites were active (having >100 birds) at any one time. Although these are not always the same sites, six sites had a significantly higher frequency of occupancy than others, and lack of occupancy of these primary sites appeared to be associated with the occupancy of nearby alternative sites. *Received 22 June 1995, accepted 3 February 1996.*

Key words.—Censusing, Double-crested Cormorant, *Phalacrocorax auritus*, winter roosting populations.

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During the past decade, increases in breeding Double-crested Cormorant (*Phalacrocorax auritus*) populations have been well documented (Scharf and Shugart 1981, Milton and Austin-Smith 1983, Buckley and Buckley 1984, Hatch 1984, Ludwig 1984, Blokpoel and Harfenist 1986, Price and Weseloh 1986, Roney 1986, Craven and Lev 1987, Hobson *et al.* 1989, Weseloh *et al.* 1995). Summarization of these data has indicated annual population increases of 15% to 63%, most notably in the Great Lakes and northern prairie region (Dolbeer 1990). Between 38% and 70% of birds from these regions appear to winter in the lower Mississippi Valley, primarily on the Gulf Coast (Dolbeer 1991). Historically, wintering populations of cormorants in the fresh waters of the lower Mississippi River drainage have been small (Lewis 1929). However, increases in these populations during the 1980s were documented in Washington County, Mississippi during Christmas Bird Counts (CBC; American Birds, 1981- 1988, Volumes 35-42) that parallel reported increases in breeding populations. During this same period, Dolbeer (1990) estimated that approximately 120,000 cormorants were migrating through this area with potential increases of 20,000 birds annually. However, little was known about the actual numbers wintering in the Delta Region of Mississippi. These populations have been of particular concern because of their potential for conflict with catfish farming in this region which, with approximately 40,000 ha of ponds, is the most concentrated area of aquaculture production in the United States (Glahn and Stickley 1995). This industry rapidly increased during the 1980s (MCES

1990), but growth has slowed since 1989 and slightly decreased in 1992 (USDA 1993).

During the winters of 1989-90 and 1990-91, Aderman and Hill (1995) conducted preliminary investigations to identify winter roost sites and examined procedures for enumerating populations at these sites. Concurrently, USDA Animal Damage Control personnel conducted independent surveys of cormorant populations using slightly different procedures at known roost sites in February of each winter (Aderman and Hill 1995). Throughout the course of their investigations, Aderman and Hill (1995) identified new roosting locations totalling 18 sites, and subsequently added most of these to their population surveys. However, it was unclear at the end of their study how many additional roosting locations might remain to be identified or whether they would contribute substantially to the total wintering populations. The purpose of the present study was to address these questions and to develop or refine procedures that might be used to accurately assess cormorant populations wintering in the Mississippi Delta Region. We also examined current trends in wintering cormorant populations and their patterns of roost site occupancy.

METHODS

The Mississippi Delta Region, occupying approximately 16,000 km^2, is the flood plain of the Mississippi River and its tributaries, the Yazoo, Sunflower, and Tallahatchie rivers. Although much of the Delta has been drained for agricultural purposes, more than 10% of the original wetland area remains, consisting of cypress swamps, oxbow lakes and bayous. These areas are associated with river drainages and provide night roosting habitat for cormorants (Aderman and Hill 1995).

Our study was conducted during the winters of 1991-92 and 1992-93. Methods of locating roosts varied between years, but methods of surveying cormorant populations at known roost sites were identical. Population surveys were conducted in mid-December, mid-February and the end of March, at about the same time each year to correspond with sampling periods used previously by Aderman and Hill (1995). Due to manpower constraints, Aderman and Hill (1995) conducted their surveys over a period of up to seven days. In contrast to Aderman and Hill (1995), survey counts of all identified roost sites were conducted over a 24 h period. We counted cormorants arriving at these sites during the evening of the first day and completed most of the counts at other sites the following morning. A few sites were then counted the following evening, if necessary. To accomplish this task over the shortest time period possible, we deployed 12-15 experienced observers, primarily USDA Animal Damage Control personnel, but also included personnel from the U.S. Fish and Wildlife Service and other State and Federal agencies.

Using counting procedures described by Aderman and Hill (1995), we identified suitable locations that provided a full view of cormorant flightlines as they arrived or departed the roost. At most locations, one observer from a roadside location was adequate, but other sites required either 2 observers or an observer in a boat. Timing of counts were based on previous observations by Aderman and Hill (1995) and from cormorant telemetry studies (King *et al.* 1995) suggesting times of arrival and departure from roost sites. For morning counts, observers were at their counting locations before sunrise and observed for cormorant flocks departing until 3 h after sunrise. For evening counts, the observers were at their counting positions 3 h before sunset and remained until dark. Exceptions occurred when the entire roost site could be observed directly and observers could discern when no cormorants were present at sunrise or sunset. Observers counted or estimated (Arbib 1972) numbers of cormorants as flocks slowly arrived or departed the roost site and kept a running total on a data form or with a mechanical counter. If small flocks could be observed in the roost prior to the start of an evening count or after the end of a morning count, these were estimated and added to the totals.

In 1991-92, we located new roost sites primarily by soliciting observations from Animal Damage Control biologists, fish farmers and other cooperators. Some reports resulted from a telemetry study to determine the daily activity budgets of cormorants (King *et al.*, 1995). In 1992-93, we continued to solicit information through news releases, but focused on aerial reconnaissance. This involved both aerial tracking of transmitter-equipped cormorants (King, unpubl. ms.) and systematic aerial surveys of the study area that examined existing sites and potential sites along drainages of the Mississippi, Yazoo, Sunflower and Tallahatchie rivers. These surveys were conducted in a Cessna 172 at an altitude between 500 and 700 feet during the last 3 hours before sunset. To cover the study area, at an approximate flight speed of 160 kph, two consecutive evening flights were necessary. Flights were guided by topographic maps and aerial photographs of the area that identified possible suitable habitat. Two observers counted or estimated cormorants on each side of the plane. To better assess whether or not these locations were night roost sites, the time of the count and the presence of birds in trees or in the water was also recorded. These aerial surveys were conducted approximately one week before ground surveys in December, February and March. Sites identified from aerial surveys and other means were included in subsequent ground surveys.

Correlation analysis compared aerial counts with ground counts made approximately one week apart. Using a 2-way ANOVA, population data collected during this study and that reported by Aderman and Hill (1995) were compared among years and months. Further, we examined the frequency of roost site occupancy using Chi-square analysis to help identify primary roost sites.

RESULTS

Numbers of additional roost sites identified varied annually, according to methods used and other factors. In 1991-92, five additional night roosts were identified, for a total of 23 sites being surveyed after December (Table 1), but only three were actually new sites. Two of these had previously been identified as day roosts, but not reported as night roosting locations. Of these only one site had populations consistently over 100 birds, but always contained less than 1,000 birds each survey period. In 1992-93, 11 more roost sites were located, for a total of 34 sites monitored before the last survey in March. Seven of these new sites contained greater than 1,000 birds at some time during 1992-93, probably in response to roost harassment efforts at several selected traditional sites in the area (Mott *et al.*, unpubl. ms.). Following these human harassment efforts, populations shifted away from these harassed sites and the resulting new sites contained most of the Delta-wide cormorant populations during the mid-February and late March surveys.

The use of aerial surveys was associated with an increase in the number of new roost sites identified in 1992-93. This method accounted for almost half of the new sites identified. All sites identified in our study, with the exception of one, were associated with drainages of the Mississippi, Yazoo, Sunflower and Tallahatchie rivers (Fig. 1). Thus, these rivers were effective guides to flight planning. The presence of cormorants in trees within 2 h before sunset was a good indication of a night roost. Earlier cormorant presence was often indicative of a day roost; and birds observed on the water was more often associated with foraging than roosting. Using this roost criterion, estimates of cormorant night roosting populations from aerial counts were significantly ($r_{27} = 0.973$, $P = 0.0001$) correlated with ground counts of the same sites made within 8 days of each other (Table 2). A significant ($P = 0.0001$) linear prediction of ground counts from air counts took the form $Y = 279.0\ a + 1.38\ b$, where a is the Y intercept and b is the slope.

Despite increasing the monitoring effort and shifts in roosting populations to previously unidentified sites, there was no significant change ($F_{3,2} = 2.26$, $P = 0.182$) in censused cormorant population size over the 4 year period (Table 1). However, there were significant ($F_{2,3} = 28.72$, $P = 0.0008$) differences in populations censused among months. Means of February counts were different (Duncan's Multiple Range Test; $P <$

Table 1. Double-crested cormorant population sizes, number of sites surveyed and the number of active sites located in the Delta Region of Mississippi during the wintering seasons of 1989-90 through 1992-93.

	Wintering Season			
Month	1989-90	1990-91	1991-92	1992-93
December				
Population Size	16560[1]	11856[1]	12560	11441
Sites Surveyed	9	15	21	26
Sites Active[2]	3	6	8	12
February				
Population Size	28484[3]	31072[3]	27352	31915
Sites Surveyed	13	18	23	29
Sites Active	9	12	11	8
March - April				
Population Size	24660[1]	13416[1]	13490	19526
Sites Surveyed	13	18	23	34
Sites Active	7	7	8	12

[1]December and March-April counts from Aderman and Hill 1995.
[2]Number of sites with counts >100 birds.
[3]Mid-February counts conducted by USDA Animal Damage control personnel.

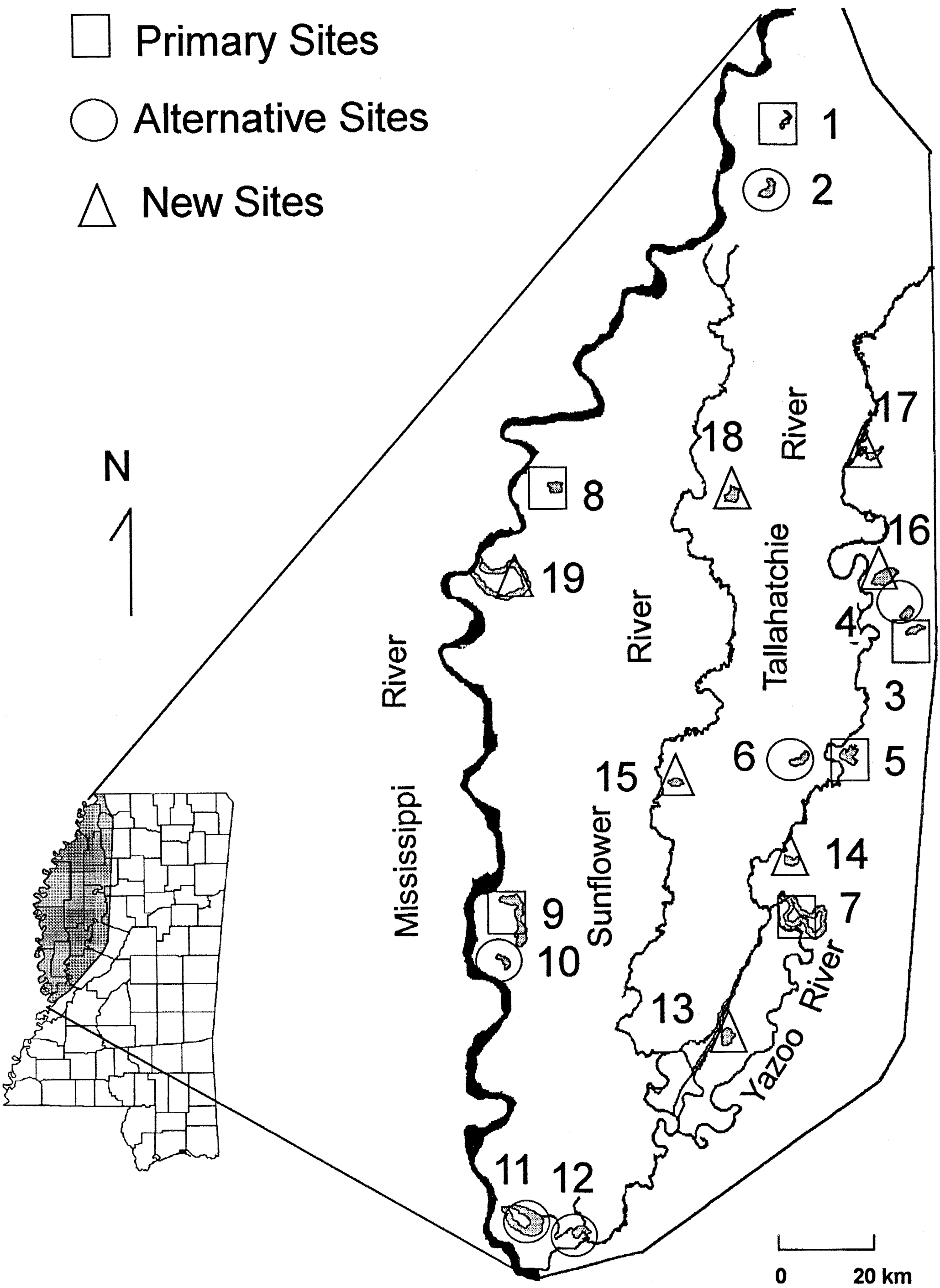

Figure 1. Distribution of primary, alternative and major (>1,000 birds) new Double-crested Cormorant roost sites within the Delta Region of Mississippi during the winters of 1991-92 and 1992-93. *Primary Sites*: 1 = Beaver Dam Lake; 3 = Sharkey Bayou; 5 = Mathews Brake; 7 = Bee Lake; 8 = Bolivar County Lake; 9 = Lake Washington. *Alternative Sites*: 2 = Phillips Bayou; 4 = Goose Pond; 6 = Little Mossy Lake; 10 = River Chute; 11 = Eagle Lake; 12 = Issaquena County Bayou. *New sites*: 13 = Broad Lake; 14 = Little Eagle Lake; 15 = Dutch Brake; 16 = Six Mile Lake; 17 = Buzzard Bayou; 18 = Grittman Brake; 19 = Lake Whittington.

Table 2. Aerial and ground survey counts of double-crested cormorants at roost sites in the Delta Region of Mississippi where cormorants were in trees during aerial counts made within the last 2 h before sunset and ground surveys were made within 8 days after aerial surveys.

Month/Site	Counts of Cormorants from Aerial and Ground Surveys	
December 1992	Aerial Counts	Ground Counts
Grassy Patch	0	0
Lake Bolivar Co.	200	157
Lake Washington	2500	4097
Eagle Lake	100	290
Halpino Lake	250	130
Broad Lake	0	933
Whittington channel	0	2
Arkabutla Lake	0	0
February 1993		
Lake Washington	2	4
Beaver Dam	3	1303
Buzzard Bayou	400	1951
Eagle Lake	0	9
Halpino Lake	0	0
Issaquena County	0	0
Broad Lake	0	0
Mathews Brake	0	29
Little Mossy	0	0
Dutch Brake	10,000	13,804
Arkabutla Lake	50	145
March 1993		
Sharkey Bayou	0	0
Goose Pond	0	0
Mathews Brake	0	0
Tchula	0	0
Little Eagle	300	2607
Bee Lake	3	0
Dutch Brake	300	1530
Sky Lake	100	225
Whittington Channel	5	0
Broad Lake	900	3160

0.05) from those of both December and late March.

Despite the increase in the number of monitored sites, at any given time the number of active sites that contained >100 cormorants did not increase over time, but remained at between six and twelve after most of the sites were identified in 1990-91 (Table 1). However, the sites were not always the same. Of the 18 sites identified by Aderman and Hill (1995), six sites appeared to be primary sites by virtue of being active 61-100% of the 18 times surveyed. The activity threshold was defined as populations exceeding 100 birds during roost counts conducted from November through April, because roost site populations of <1,000 birds constituted a large percentage of the total population during some surveys. Two counts made in February and March of 1993 were excluded because known harassment efforts at several of these primary sites may have influenced this pattern of occupancy. There was a significant (χ^2_1 = 65.7, $P <$ 0.0001) difference in the frequency of occupancy between these primary sites and all other sites. These primary sites have also had some of the largest populations reported during the 4-year study, peaking at between 2,000 and over 9,000 birds (Table 3). These

Table 3. Double-crested cormorant roost counts of six primary roosting sites and six alternative sites in the Delta Region of Mississippi during studies by Aderman and Hill (1995) and this study. Primary sites (in bold lettering) are followed by a hyphen when a paired alternative site is present.

	Double-crested Cormorant Roost Counts by Month/Year										
Roost site	4/90	12/90	1/91	2/91	2/91[1]	3/91	4/91	12/91	2/92	3/92	12/92
Bee Lake	1083	1524	7977	1262	9183	5381	528	2370	6785	176	3500
Bolivar Co. Lake	108	344	662	1811	2003	712	26	819	1786	450	157
Beaver Dam -	0	1508	254	1239	2221	8273	2367	615	7047	350	674
Phillips Bayou	7200	0	0	0	0	0	0	0	1	3834	0
Sharkey Bayou -	5343	0	0	8877	9150	4180	7451	991	5510	6952	300
Goose Pond	0	0	0	0	0	1673	16	390	0	0	97
Mathews Brake -	2281	5791	0	2850	1463	5987	18	32	0	83	0
Little Mossy	NC[2]	0	2663	0	0	0	0	0	0	0	0
Lake Washington -	6314	0	5682	3616	4000	0	0	3230	3199	70	4097
River Chute	NC	NC	NC	NC	NC	3000	855	0	0	190	480
Eagle Lake	0	2443	5500	1216	1410	0	0	0	0	0	290
Issaquena County Bayou	0	184	500	0	0	0	0	650	250	0	250

[1]Mid-February count conducted by Animal Damage Control personnel.
[2]No count of this site during this survey period.

sites are larger permanent lakes and bayous that support large stands of roosting trees over standing water. All of these primary sites also offered a large area of adjacent open water that cormorants often used for foraging.

When primary sites were inactive, a nearby alternative site was more likely to be active. This was the case during the winters of 1989-1990 and 1990-1991 with Beaver Dam and Phillips Bayou, with Mathews Brake and Little Mossy Lake and with Lake Washington and River Chute (Table 3). The case for the fourth alternative site (Goose Pond) is less clear from the data possibly because it is part of a series of interconnected sites that may have been overlooked in the past. However, roost harassment efforts at the primary site (Sharkey Bayou) have suggested a similar relationship here. These alternative sites were consistently less than 15 km from the primary sites, whereas primary sites were greater than 28 km apart and widely distributed throughout the Delta (Fig. 1). Similarly in response to roost harassment efforts and other factors, most new roosts formed in close proximity to inactive primary sites (Fig. 1). This was true for Bee Lake and Bolivar County Lake, where no alternative sites had been previously identified (Fig. 1). The association of alternative sites with primary sites was not always clear. This was the case with a pair of closely associated sites (Eagle Lake and Issaquena County Bayou) in the extreme southwest part of the study area (Fig. 1). Each site has been occupied only five times (Table 3). This was comparable to the occupation of other alternative sites, but based on frequency of occupation, neither would be considered a primary site. These sites were considered alternative sites, because they were alternatives to each other, as well as other possibly undetected sites outside the study area. The combination of these six primary sites and six alternative sites constituted between 72% and 97% of the total birds counted on all surveys through December 1992 (Table 3). With the exception of these, other sites monitored were only rarely occupied.

DISCUSSION

Adequately censusing wintering cormorant populations at their night roost sites, requires that all of their alternative sites are identified prior to the census. Aerial surveys of primary river drainages during the 2 h before sunset appeared to meet this requirement. Further, aerial surveys appeared to accurately predict the presence or absence of significant roosting populations, but not necessarily actual numbers of cormorants present. An actual change in populations over the time of span of 8 days between surveys may have produced the variation observed.

Despite a concerted effort to identify additional cormorant roosting areas, possibly missed by Aderman and Hill (1995), few sites containing any substantial numbers were located before initiation of a roost harassment efforts directed at traditional sites in the region. Although some new sites were identified during our study, there was no difference detected in overall populations among 4 years of surveying populations. Peak populations consistently occurred in mid-February and numbered approximately 30,000 and varied by approximately ± 2,000 individuals. In contrast, Aderman and Hill (1995) reported peak populations to occur in March and April. This seasonal difference appeared to result from Aderman and Hill's surveys not identifying major sites until after February. However, these same sites were included in mid-February surveys conducted by USDA Animal Damage control personnel in our study. Based on the increased monitoring in 1991-92 and 1992-93, it appears that populations in the study area have not increased, but have either remained relatively stable or possibly decreased. A population decrease would assume that substantial numbers of roosting birds were missed during previous surveys and we have no evidence of this.

The stability of cormorant populations in recent years is consistent with the lack of any detectable trend in cormorant populations from CBC counts in Washington Co. Mississippi since 1988 (American Birds, 1989-1992, Volumes 43-47). In contrast, trends from these data during the 1980s suggested increasing populations that paralleled the growth of the catfish industry in this region during those years. As the growth of the catfish industry has slowed (USDA 1993), so has the apparent growth of wintering cormorant populations in the Delta Region of Mississippi. Also in recent years, catfish farmers in the region have increased efforts to control cormorant predation on catfish by patrolling their ponds and harassing foraging cormorants. These actions may have limited the further exploitation of fish resources in the region by wintering cormorant populations.

Aderman and Hill (1995) noticed considerable within-site fluctuation in roosting populations among surveys. In part, they attributed population fluctuations to human disturbance. Our results confirms that immigration of birds into the region as well as shifting populations among alternative sites can drastically change populations at a given site. However, our analysis suggests that certain sites are preferred and much of the short-term fluctuation may simply be shifts among primary and alternative sites. Also, human disturbance directed at primary sites can be a major cause of cormorants shifting to alternative sites.

Migration and mid-winter immigration into the Delta appear to be primary factors in regional population fluctuations. Although extreme weather conditions may be another important factor affecting cormorant populations (Aderman and Hill 1995), we did not observe such extremes during our study. Peak immigration into the area appears to occur between mid-December and mid- February. By the end of March, populations are significantly reduced. This seasonal trend in the wintering population fluctuations parallels that of the Great Cormorant in the northern part of their wintering range in France (Yesou 1991) and Switzerland (Suter 1991). Although the reduction of cormorants at the end of March is consistent with their arrival on the breeding grounds in April (Weseloh and Ewins 1994), the influx of birds during mid-winter remains unclear. We speculate, however, that these are birds from more southern wintering areas that congregate here prior to their northward migration.

Aderman and Hill (1995) reported that roost habitat characteristics included the availability of suitable roosting trees, primarily large bald cypress (*Taxodium distichum*) and open water adjacent to or around them, but that the size of the body of water seemed unimportant. Our analysis suggests that there are a small number of primary sites within the region that are preferred by roosting populations of cormorants. Preferred sites were characterized by having a large area of adjacent open water. Furthermore, roosting habitat available at preferred sites, typically bald cypress, was large (>35 ha) and characteristically surrounded by permanent standing water. In contrast, alternative and new sites identified had smaller permanently flooded roosting areas or were only intermittently flooded. A percent tree cover of less than 50% was common among all sites identified and was probably indicative of the larger trees that seems to be required by roosting cormorants.

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